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Description

INTERLOCKING HONEYCOMB-CORED PANEL SYSTEM FOR CONSTRUCTION OF LOAD SUPPORTING SURFACES

BACKGROUND OF INVENTION

[0001] The present invention relates to a reusable panel system for the construction of load bearing surfaces, such as temporary or semi-permanent roadways and equipment support and work surfaces laid out over geologically unstable surfaces or over wet-land marshes.

[0002] When performing operations with heavy equipment in a remote location, it is often necessary to provide a firm, stable and continuous surface to support such equipment. For example, when drilling an oil or gas well in a remote location, it is often necessary to provide work surfaces used during the drilling process. It is also advantageous to provide one or more roadways to allow access to and from the well-site. Such a surface should be able to support the very heavy equipment used in such operations and able to

withstand sever weather. Often the ground is wet and they may include marsh, bog, and/or slippery clay earths. The panels should be easy to install and able to provide sufficient support to allow operations under severe and difficult ground conditions. The panels may also be easily removable, with minimal impact to the surrounding environment.

[0003] Historically various solutions have been used to meet these requirements. Each has its advantages and disadvantages.

[0004] In the past, roadways were made of planks, boards or logs laid out in various configurations and often nailed together. These roadways required an immense amount of labor to complete and were essentially impossible to remove. There are many areas throughout the wilds of Canada and the United States where evidence of these roads can be found 50 or more years after they were initially used.

[0005] An improvement on these systems is the construction of wooden mats, often made of Oak, constructed and nailed together at a factory location and then transported to the field. The mats are then interconnected and nailed together to provide a more or less continuous surface. How-

ever, the gaps in the materials allow the wet ground under the mat to "pump" material up through the gaps as heavy equipment moves over the surface. This creates a void in the ground under the mat and causes the mats to break and splinter. Further this "pumping" action often causes the mat to be buried, necessitating the addition of further layers of mats. These shortcomings result in mats that are difficult to remove when the work is finished. Another disadvantage is the weight of the mats themselves, when new and dry they are often over 2,000 lbs each, when used and wet the weight can more than double. This requires the use of very heavy equipment to move and position the mats.

[0006] A further difficulty with these wood mats is they suffer from significant rotting problems. This rotting, coupled with the foresaid difficulty of breaking and splintering of individual boards causes significant expense in repairs and maintenance to the mats.

[0007] Often wooden and other mats systems are not substantially connected together. As vehicular traffic moves across the surface the mats may separate or "walk" apart. The resulting discontinuous surface creates hazards for transportation and workers, further it exacerbates the

"pumping" action of the mats.

[0008] Recently some polymeric load bearing mat systems have been proposed. For example, U.S. Patent No. 4,629,358 to Springston discloses a mat system for the construction and repair of airfield surfaces. It is made of fiberglass re-inforced plastic and is filled with hollow inorganic silica spheres.

[0009] U.S. Patent No. 6,695,527 to Seaux et.al. discloses a mat system useful to create a load bearing ground surface. The mats of the system are formed to be laid out over a surface with overlapping edges. The mats are each formed of two halves, an upper half and a lower half. The halves include a surface, which will face outwardly on the final mat, and a honeycomb surface, which will be positioned inside the mat when the two halves are secured together to form the mat.

Summary of Invention

[0010] A panel system has been invented for use in the construction of load bearing ground surfaces.

[0011] In accordance with a broad aspect of the present invention, there is provided a load bearing structure comprising a panel having at least three sides. The panel can be formed of a honeycomb core located between the upper

and lower surfaces of the panel. A continuous layer can surround the honeycomb core. One or more connector means may be located on at least one side of the panel.

[0012] Selected edges of the panel may, in one embodiment, have a wedge-shaped configuration. In another embodiment, the panel may include a lapping ledge along one or more selected edges.

[0013] If desired, a panel can be textured, treated and/or coated with a variety of slip-resistant and/or chemical and/or fire resistant coatings to meet the needs of various applications. Furthermore, the panels may be colored to provide high-contrast surfaces in order to enhance visualization of the ground support.

[0014] In a further embodiment, the panel can be modified to include stress-strain sensors that can function to give real-time telemetric data useful in determining the response of the panel under particular field load scenarios.

[0015] A light-weight panel is thereby produced with consequently exceptional handling capabilities.

Brief Description of Drawings

[0016] Various embodiments of the invention are illustrated in the following drawings:

[0017] Figure 1 is a top plan view of a load supporting panel hav-

ing a wedged-shaped edge configuration.

[0018] Figure 2 is a side elevation view of the panel of Figure 1.

[0019] Figure 3 is an end elevation view of the panel of Figure 1.

[0020] Figure 4 is a section view of the panel of Figure 1 connected to a second panel.

[0021] Figure 5 is a top plan view of a plurality of load supporting panels connected together.

[0022] Figure 6 is a side view of two load supporting panels connected together.

[0023] Figure 7 is a top plan view of an alternative embodiment of a load supporting panel having a wedge shaped edge configuration.

[0024] Figure 8 is a top plan view of an alternative embodiment of a load supporting panel having a wedge shaped edge configuration.

[0025] Figure 9 is a top plan view of a plurality of alternatively configured load supporting panels connected together.

[0026] Figure 10 is a top plan view of a load supporting panel having a lapping ledge configuration.

[0027] Figure 11 is a side elevation view of the panel of Figure 10.

[0028] Figure 12 is an end elevation view of the panel of Figure

10.

[0029] Figure 13 is a sectional view along line XIII XIII of Figures 1 and 10.

DETAILED DESCRIPTION

[0030] The panels of the present invention may offer a durable, reusable system for construction of roadways and other ground support surfaces. The panels can be assembled to create work surfaces of various dimensions. Because the panels are designed to interlock with one another they can be connected together in a wide number of combinations to provide the correct alignment for any ground support application. This flexibility of assembly, along with the durability of the panels allows for quick and easy installation, usually requiring only one layer of panels on virtually any ground substrate. The panels may be formed to be positively buoyant to float on water, to enhance their usefulness.

[0031] Referring to Figures 1 to 3, a panel useful in the system is provided with an expansive upper surface 10 and a lower surface 12. A panel may include a wedge-shaped edge 14 along one or more selected edges. In the embodiment shown, all the sides of the panels have a wedged-shaped edge. A wedge-shaped edge may be either descending

(from the top to the bottom of the panel) or ascending (from the bottom to the top of the panel) in order to permit an edge of one panel to be overlapped or underlapped with an adjacent panel. For example, the side edge surface of the panel may intersect with the upper and lower surfaces at other than 90° such that the thickness tapers. It may be useful to form the panels with corresponding wedge-shaped edges, such that they can be fit together.

[0032] A panel may be connected to one or more other panels through connector means. In one embodiment, the connector means may be located around the perimeter of the panel, such that each panel can be connected to other panels in a wide array of different configurations. For example, the connector means may be located between 2 and 14 inches from the outside edge of the panel. In the panel illustrated, the connector means are alignment apertures 16 that extend through the panel between the upper surface 10 and the lower surface 12 of the panel. Such apertures are formed to align with apertures on other panels to be joined together and to accept and retain a fastener or other component, such as a screw, bolt, rivet, pin, lock, nail, stake, wire, etc. Figure 4 shows a descending wedged shaped edge 14 of one panel and an as-

cending wedged shaped panel of a second panel 18 joined by connecting means that includes apertures 16 through the panel and an assembly that includes a bolt 20 and a nut 22 each having flanged edges that engage the panel about the aperture. In the illustrated embodiment, apertures 16 are positioned on the wedge shaped edge 14. By joining the panels, multiple panels become effectively a coacting surface suitable (as previously described) for use as road or work platforms on a variety of terrains. Other connector means may be used including but not limited to: apertures formed to accept and retain lock pins, such as those shown in US Patent application 2002/0187017 or other pins; pins formed or mounted on one panel edge and holes to accept the pins on other panel's edges to be joined together; hook and loop fasteners, such as Velcro™; removable rivets; clips; buckles; clasps; clamps; braces; grips; locks; nails; stakes; wires; etc. The connector means may be formed on the panel, connected to the panel during manufacture or separable therefrom, as desired, with possible consideration as to the form of connector means used.

[0033] Referring to Figures 5 and 6, a plurality of panels can be laid over a ground surface in a single layer with their

edges 14 overlapping. The individual panels of said system are restrained from horizontal movement by frictional contact with the underlying terrain, by mechanical contact and connection with adjoining panels, as by engagement by connector means 20 and, where necessary, by affixing the individual panels to the ground by other mechanical means such as with stakes.

[0034] The panels of the present invention may be impermeable, so that fluids cannot seep into or through the body of the panels. This reduces and may eliminate the "pumping" action associated with some other work mats as described previously. By reducing pumping action the panels may also be easier to pick up for reuse and may cause only minimal ground disturbance after they have been removed.

[0035] Each panel may be formed with a continuous outer surface, such that there are no gaps or channels for the accumulation of mud, ice and other debris.

[0036] The dimensions of the panels of the present invention can easily be varied with changes to production tooling. In one embodiment, the panels may be 7.5 feet by 14 feet so that they can fit into an ISO standard container. The work surface of each such panel when assembled with adjacent

panels overlaid and attached can be 6.5 feet by 13 feet.

[0037] Other sizes and shapes of panels can be easily manufactured in order to customize the panels for particular applications. Panels of different dimensions can, for example, be constructed to allow for curves, slopes and other deviations in roadways and other surfaces. Figures 7 and 8 show for example, a panel having a trapezoidal configuration having a short end edge 26 and a long end edge 28 and side edges 30. It should be stressed again that other configurations could be manufactured. All edge lengths may be varied as shown between Figures 7 and 8. As well, panels having various different thickness may be used. Figure 9 shows a plurality of panels of different dimensions interconnected to one another so that they can be laid to form a curved roadway or other deviated surface.

[0038] Figures 10 to 12 refer to an alternative embodiment of the panel. In this embodiment, the panel useful in the system may be relatively thin with an expansive upper surface 36 and lower surface 32. The panel may include a lapping ledge 34 along one or more selected edges. Lapping ledges 34 may be less than the full thickness of the panel to permit an edge of one panel to be overlapped or underlapped with an adjacent panel. It may be useful to form

the panels with corresponding lapping edges, such that they can be fit together. For example, each panel may include a ledge extending from its upper surface 38 on one or more sides and a ledge extending from its lower surface 34 on one or more other sides. In one embodiment, each panel may be formed as a square or rectangle and may include a ledge extending from its upper surface on two adjoining sides and a ledge extending from its lower surface on the other two sides. These ledges may be substantially one half the panel edge thickness so that the ledges can be overlapped. The ledges may extend out from the panel edge a distance, for example about one foot, that creates some resistance to mud and liquids passing through the interface of the lapped ledges.

[0039] Connector means may be molded into the panel or connected to the panel during manufacture. In the embodiment shown, substantially rigid projections 37 such as a pin, bolt, screw, etc, are connected to or form part of the ledge extending from the lower surface of the panel 34. Apertures 16 located on the ledge extending from the upper surface of the panel 38 are formed to accept and retain the substantially rigid projections 37 of an adjacent panel.

[0040] The edges of the panel may also be reinforced to constrain any compression at the edge of the panel and to protect the edge of the panel from damage. This edge reinforcement may be provided in various ways and from various materials including but not limited to: fiber reinforced materials, such as for example, pultruded fiberglass, polymeric rods, for example various plastics (such as polyolefin), wood, steel, aluminum and other commonly available commercial materials suited to the requirement. The reinforcement material may be placed at various points of the edge of the panel, incorporated into the wedge itself, placed parallel to the wedge on the vertical plane, etc.

[0041] The present panel may include a honeycomb core and a fiber reinforced layer thereon. In one embodiment, a honeycomb core manufactured of polypropylene thermoplastic is sandwiched between layers of fiber reinforcements. In other embodiments, the honeycomb core material may be selected from a variety of commercially available core materials including metal such as aluminum honeycomb, resin reinforced paper honeycomb and other commercially available honeycomb core materials. The reinforced layer may completely surround the honeycomb-core so that it

is not open on the edges of the panel, thus forming a continuous layer.

[0042] Fiber reinforcements are available in a large number of fiber arrangements each with different characteristics that can be used to produce desirable properties in variants of the present invention. For example, stitch-fiber matting may be utilized in order to increase the compression strength of the panel. Reinforcing fibers may include fiberglass, carbon fiber, aramid fiber, or other commonly available reinforcing fibers can be used alone or in combination. These reinforcing fibers can be impregnated with an adhesive and placed onto the honeycomb core, or placed on the honeycomb core and infused with an adhesive. The panel may also be manufactured with the use of thermoplastic adhesives.

[0043] A panel can be textured, treated and/or coated. Slip-resistant and/or chemical and/or fire resistant coatings/treatments may be used to meet the needs of various applications. Additionally, the materials of the panels, such as the coatings, may be colored to provide high-contrast surfaces to enhance visualization of the ground support. A panel can be recoated at any time should the coating become ineffective due to wear or some other cause.

[0044] Referring to Figure 13, a panel is shown in section. The panel includes: a slip resistant coating 46, such as sand particles (sand particles 20 mils in diameter in about 5 mils of paint, for example); a surface coating 47, such as paint (10 mils of paint, for example); a fiber reinforced layer 42 (including two layers of fiber glass mat in epoxy, each layer about 1/16 inches thick, for example); a honeycomb layer 40 (4 inches of honeycomb with 5/16 inches straws, for example); fuzz on top of the honeycomb core with epoxy 44 (about 5 mils of epoxy, for example); and barrier film 45 (5 mils of barrier film, for example) for reducing infiltration to the honeycomb layer 45. It is important to stress that these are examples and not limitations.

[0045] While the present invention provides a panel system for the construction of load bearing surfaces, such as roads or work areas on unstable ground surfaces, it can also be applied for use over conventional roadways and road and work surfaces to increase the load bearing capacity of the surface. The panels are light weight. Consequently, with minimal equipment and manpower, the panels can be interlocked to provide said work surfaces that may exhibit durability and strength and then can be disconnected, picked up and transported to another site for reuse. The

panels can be manufactured using a variety of techniques, from molded thermoplastics to fiber-reinforced composite structures made with thermoset resins.

[0046] The panels can be altered to make them useful in other applications such as trench covers, airport taxiways, floors for portable buildings, walkways, portable docks, trench shoring, or other such uses as become apparent. These alterations can involve resizing the honey-comb core, the reinforcement layer, or the use of different outer coatings.

[0047] To produce a panel, a mold may be manufactured, for example, out of light gauge steel. The mold may be tightly sealed to prevent air leakage during the vacuum phase of the manufacture. The inside surface of the mold can be textured either by directly embossing the steel, or by adding a layer of plastic that has the reverse image of the desired surface texture. This mold inside surface forms the top surface of the panel. The inside of a vacuum bag used during the vacuum phase of the manufacture forms the bottom surface of the panel. This technique is well known in the art as "vacuum-bag" layup.

[0048] The inside of the mold may be sprayed or waxed with a release compound, which is a material to which the adhesives used in the manufacture of the panel will not easily

stick. This may be done to facilitate removing the panel from the mold after it has cured. Reinforcing fiber materials, such as for example, fiber reinforcing cloth can then be positioned in the mold. The cloth may be trimmed to fit the inside of the mold.

[0049] The fibers may be positioned before or after saturation with an adhesive material, which may be, for example, an epoxy resin. In one embodiment, a resin system may be used that is supplied by Dow Chemical available as Dow Durakane 331 Epoxy™. Such a resin may, in one embodiment, be cured using Dow Jeffamine D-320™with the addition of an accelerator manufactured by Huntsman Chemical called Accel 399™.

[0050] The polypropylene honeycomb core may then be set into the mold on top of the reinforcing fiber materials. In one embodiment, the honeycomb core may be that supplied by Plascor and known as PP30-5-2™ Polypropylene Honeycomb Core. PP30-5-2 has material density of roughly 5 pounds per cubic foot of core. The core may be treated for adhesion to the fiber reinforcing material using various techniques known in the art. This treatment may be used to increase the adhesion of the reinforcing fiber to the core and can enhance the physical properties of the

resultant panel. The honeycomb core extends over most of the finished panel. For example, in one embodiment, the honeycomb core can extend to approximately 90-95% of the overall size of the finished panel.

[0051] Prior to setting the honeycomb core into the mold a reinforcing edge may be applied to the sides of the honeycomb. This reinforcement may include any of various materials. In one embodiment of the present invention, the material used is a plastic such as polyolefin thermoplastic, (which can be in a triangular or rectangular form, for example), adhered with mastic, for example, made up of the epoxy resin formula and INHANCE™PEF fibers made of high-density polyethylene (HDPE) fibers. This product is manufactured by the Inhance Group of Fluoro-Seal International, LP. The fibers will be imbedded in the polyolefin.

[0052] With regards to the panel having the wedge shaped edge configuration, the wedge may be constructed by machining the honeycomb core to form the wedge configuration after the reinforcing edge is applied. Other techniques to forming a wedge shaped edge may also be employed. For example, a separate wedge could be constructed from any rigid material, (such as plastic, etc.) and then adhered to the sides of the honeycomb layer prior to applying the

layer of reinforcing fiber. This could involve pultruding the entire wedge and then adhering a corresponding honeycomb cut profile into the pultrusion. The wedge may then be adhered with, for example, mastic to the honeycomb core.

[0053] A second layer of reinforcing fiber and adhesive, such as epoxy, may then be laid on top of the honeycomb core. Corners and or edges may be finished by folding them in on themselves.

[0054] One or more materials, may be applied on top of the second layer, as will be appreciated, to allow the panel to be vacuum bagged and when cured ease the release of the various materials from the panel itself. A vacuum may then be applied to the panel and the mold. The pressure of the vacuum causes the materials in the mold to consolidate and forces any air entrained in the structure to be evacuated. The vacuum may be maintained until the chemical exothermic reaction of the epoxy system is substantially or fully complete such that the epoxy is substantially or fully cured.

[0055] The panel is then removed from the mold. The panel may then be trimmed to final specification.

[0056] Thereafter sufficient holes may be cut into the panel to

provide apertures and/or so that connector hardware, such as aperture reinforcement pins, etc. can be glued into place using any of a wide variety of adhesive suitable for that purpose.

[0057] The panel may then be coated with an industrial epoxy coating suitable for the chemical resistance and environmental resistance required for the panel, depending on its intended application. For example, resins and coatings may be selected to enhance chemical and/or fire resistance. As another example, coatings or resins may be selected to control static, should this be required. These coatings may also be colored. Anti-static features may also be added to some suitable standard coatings.

[0058] Alternately or in addition, a top-coat of anti-slip coating may applied to the panel. One coating that may be used for this purpose is supplied by Devoe Coatings and is known as DevGrip™. There are various grades of this coating available and the appropriate grade is selected depending on the end use of the panel. The anti-slip coating may be colored as well.

[0059] The panel may then be allowed to continue curing. Curing may be conducted slowly, for example over a number of days, or may be accelerated, for example, by putting the

finished panel into a heated environment. In one embodiment, curing may be conducted at a temperature of 160°F or less for up to 48 hours.

[0060] A panel is thereby produced with a reasonable weight and consequently, reasonable handling capabilities. For example, in one embodiment a panel measuring 4.29 meters by 2.31 meters by 010795 meters may weigh less than 193 kilograms (14.075 ft by 7.575 ft by 4.25 inches weighing less than 425 lbs). The panel of the present invention may have a reduced weight over previous panels by the combination of the essentially hollow honeycomb core providing spacing between thin lightweight reinforced layers that have extremely high strength to weight ratios.

[0061] As well, the panels of the present invention possess significantly better bulk properties over previous panels as a result of the materials that used are used in its reinforced layer. Bulk properties are the increased physical properties such as tensile strength, compressive strength and flexural rigidity. Further, by altering the density or materials of the honeycomb core, the cross-sectional thickness of the honeycomb core or by altering the characteristics of the reinforced layer such as: changing the type of fiber reinforcement, its makeup or the material it is made of; or by

changing the adhesive resin many of the bulk properties of the panel may be altered. For example a panel with more flexural rigidity could handle significantly more load on soft ground and could be made by the addition of more fiberglass and resin to the reinforced layer of the panel.

[0062] In a further embodiment the panel be modified to include stress-strain sensors. The stress-strain sensors can function to give real-time telemetric data useful in determining the response of the panel under particular filed load scenarios. This information could be useful in creating a modified panel to replace a panel or panels that are failing under the specific circumstances present in the field at a unique location. The stress-strain sensors may be attached to the panel by several different means, including but not limited to: encapsulating the sensors into the coating itself; or gluing the sensors onto the panel by using any of a wide variety of adhesives suitable for that purpose.

[0063] It should be understood that even though numerous characteristics and advantages of the present invention have been set forth in the foregoing description, the disclosure is illustrative only, and changes may be made in detail,

especially in matters of size, shape and arrangement of parts within the principles of the invention to the full extent indicated by the broad general meaning of the terms in which the claims are expressed.